SIMULATION TEST OF AUTOMOTIVE CONSTANT VELOCITY JOINT (CVJ) USING COMPUTER AIDED ENGINEERING SOFTWARE

MUHAMMAD ZAKI BIN ZAINAL

A thesis submitted in fulfillment of the requirements for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering

Faculty of Mechanical Engineering

University Malaysia Pahang

NOVEMBER 2008

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurently submitted for award of other degree.

Signature:
Name: MUHAMMAD ZAKI BIN ZAINAL
ID Number: MH05035
Date:

Dedicated to my beloved

Mother, Late Father and Sisters

For their support and motivation that they give

during finish this thesis

ACKNOWLEDGEMENT

First I would like to express my grateful to ALLAH s.w.t. as for the blessing given that I can finish my project.

In preparing this paper, I have engaged with many people in helping me completing this project. First, I wish to express my sincere appreciation to my main thesis supervisor Mr. Mohd Rashidi Bin Maarof, for encouragement, guidance, advices and motivation. Without his continued support and interest, this thesis would not have been the same as presented here

The next category people who help me to grow further and influence my project are the colleagues who always help me in order to finish this project. I appreciate very much to them because of the idea and information given.

Last but not least I acknowledge without endless love and relentless support from my family, I would not have been here. Mother and sisters, you all have given me the inspirations and encouragement until these days.

Thank you all.

ABSTRACT

This thesis deals with simulation test of constant velocity joint (CVJ) using computer aided engineering software. The objective of this thesis is to investigate and analyze the stress distribution of CVJ using CAE software. The thesis describes the finite element analysis techniques to predict the failure region on the CVJ and to identify the critical locations of the components. The structural three-dimensional solid modeling of CVJ was developed using the computer-aided drawing software, SolidWork. The strategy of validation of finite element model was developed. The finite element analysis was then performed using CosmosWork. The finite element model of the components was analyzed using the static stress with linear material model approaches. Finally, the stress distribution obtain from the result of analysis are employed as input for the failure region. From the results, it is observed that the analysis using CosmosWork can predict the failure region under fatigue loading. The acquired results tell the failure region occurred at the inner ball hub where it was attach to the shaft and the concentration of the stress occur at that place.

ABSTRAK

Tesis ini membentangkan simulasi penyelidikan terhadap gandar halaju malar (GHM) menggunakan perisian kejuruteraan bantuan komputer. Objektif tesis ini adalah untuk menyiasat dan mengkaji distribusi tekanan terhadap GHM menggunakan perisian kejuruteraan bantuan komputer. Tesis ini menerangkan teknik kajian unsur terhingga untuk menjangka kawasan GHM yang akan mengalami kerosakan dan untuk mengenalpasti lokasi-lokasi kritikal pada GHM. Permodelan struktur pejal tiga-dimensi bagi GHM dibangunkan dengan perisian lukisan bantuan komputer, *SolidWork*. Strategi pengesahan model unsur terhingga dibangunkan. Analisis unsur terhingga dijalankan menggunakan *CosmosWork*. Model unsur terhingga tersebut dikaji menggunakan pendekatan tekanan pegun dengan model bahan linear. Akhir sekali, distribusi tekanan yang didapati daripada analisa kajian menggunakan *CosmosWork* boleh digunakan untuk menjangka kawasan yang akan mengalami kerosakan sekiranya tekanan lesu dilaksanakan. Keputusan yang diperoleh menyatakan bahawa kawasan yang akan mengalami kerosakan adalah pada pusat bebola dalaman yang disambungkan kepada gandar dan penumpuan tekanan terjadi pada bahagian itu.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF GRAPH

LIST OF SYMBOLS

τ	-	Stress (Tau)
θ_o	-	Initial angle (Theta initial)
θ_i	-	Final angle (Theta final)
σ	-	Stress (Sigma)

LIST OF ABBREVIATIONS

CADD	Computer Aided Architectural Design
CAID	Computer Aided Industrial design
CAD	Computer Aided Design
CADD	Computer Aided Design and Drafting
CAE	Computer Aided Education
CV	Constant Velocity
CVJ	Constant Velocity Joint
DOF	Degree Of Freedom
FWD	Front Wheel Drive
OEM	Original Equipment Manufacturer
UTS	Ultimate Tensile Strength
YS	Yield Strength

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Constant velocity (CV) joints are a particular type of universal joint with the characteristic that they maintain an angular velocity ratio of exactly unity between output and input members at any angle during the revolution for a range of working joint angles [10]. Axles transmit the power from the transmission to the wheels. There are two axles on a front wheel drive car, one on the left and one on the right. Front wheel drive axles have two CV joints, one on either end of the axle. CV stands for "constant velocity", which refers to their ability to smoothly transfer power at an angle. The inner CV joint slides in and out so the axle can increase and decease in length when the car goes over bumps. The outer CV joint allows about 45 degrees rotation so the front wheels can turn to go around corners. There are many types of constant velocity joint such as Rzeppa, Bendix-Weiss, Tripot, Double Offset, and Helical or German Cross Groove Joint[7].

The life of a CV joint varies considerably; however, a typical life is around 4 or 5 years or 70 000 miles on an automobile [4]. Failure of a CV joint is typically considered to have occurred when excessive wear, predominantly in the form of small indentations or grooves in the hardened-steel race tracks, impacts joint performance. The result is usually observed as an audible "clicking" noise or excessive vibration during vehicle maneuvering. The cause may be due to failure of the elastomeric boot seal, allowing grit and other impurities in, and the lubricating media out [11], Alternatively it may he due to normal wear of any of the sliding, rolling or rotating members within the joint. These joint components experience very high loads which are often oscillatory in nature and thus prone to fatigue failure. Operating conditions vary considerably depending on the type of vehicle, size of engine, the driving conditions, the payload, and the characteristics of the driver. The effect of tolerance stack-up and the fit between mating parts created during component manufacture can also have a significant effect on wear and service life [9].

In this project, we want to describe a method to find the maximum load, torque/moment and angle for the CV joint that the component can extant when we apply it. Beside that we also want to analyze the functionality and design using computer aided engineering software (CAE). We also want to know when the CV joint become wear when we apply a load in the component and the time taken. A measuring instrument based on this work has been develop [4], and a patent application has been filed [11]. An important attribute of the new methodology is that it does not require detailed design parameters of the race. This is particularly important considering the wide range of CV joint sizes and types on the market today and the fact that most potential users of the methodology would not have direct access to this information. For the automotive aftermarket, the new methodology provides a standard measure upon which to base serviceability decisions. For the autoindustry OEMs, the methodology provides a measure which could be used to evaluate and quantify CV joint wear on new vehicles undergoing life and performance testing.

1.2 Problem statement

This project is to initiate the simulation of stress/ force using CAE. The project base on Constant Velocity Joint (CVJ) for automotive part. As the result the CVJ will move constantly with the time. When the CVJ rotate it will course the friction on the bearing in constant velocity (CV). Besides that, the load and angle also give the impact to the CVJ when it rotation. The failure/wear of the CVJ will occur when the load, angle and the friction are applied constantly or in high

1.3 Project Objective

To investigate the stress analysis of constant velocity (CV) joint using CAE software

.

1.4 Project Scopes

By stating this project base only on the objectives is not recommended as is too large or too wide to cover and it is important to create a scope for this project. Scopes of this experiment are:

i. Using CAE software to determine the computational stress and finite element
ii. General/common product in automotive industry

CHAPTER 2

LITERATURE REVIEW

2.1 Type of constant velocity joint (CVJ)

2.1.1 Rzeppa

The Rzeppa constant velocity (CV) joint is a ball- bearing type in which the balls furnish the only points or Double - Cardan universal joint - Of driving contact between the two halves of the coupling. A Rzeppa CV joint consists of a star-shaped inner race, several ball bearings, bearing cage, outer race or housing, and a rubber boot. The inner race (driving member) is splinted to the inner axle shaft. The outer race (driven member) is a spherical housing that is an integral part of the outer shaft; the balls and ball cage are fitted between the two races. The close spherical fit between the three main members supports the inner shaft whenever it is required to slide in the inner race, relieving the balls of any duty other than the transmission of power. The movement of the balls is controlled by the ball cage. The ball cage positions the balls in a plane at right angles to the two shafts when the shafts are in the same line. A pilot pin, located in the outer shaft, moves the pilot and the ball cage by simple leverage in such a manner that the angular movement of the cage and balls is one half of the angular movement of the driven shaft.

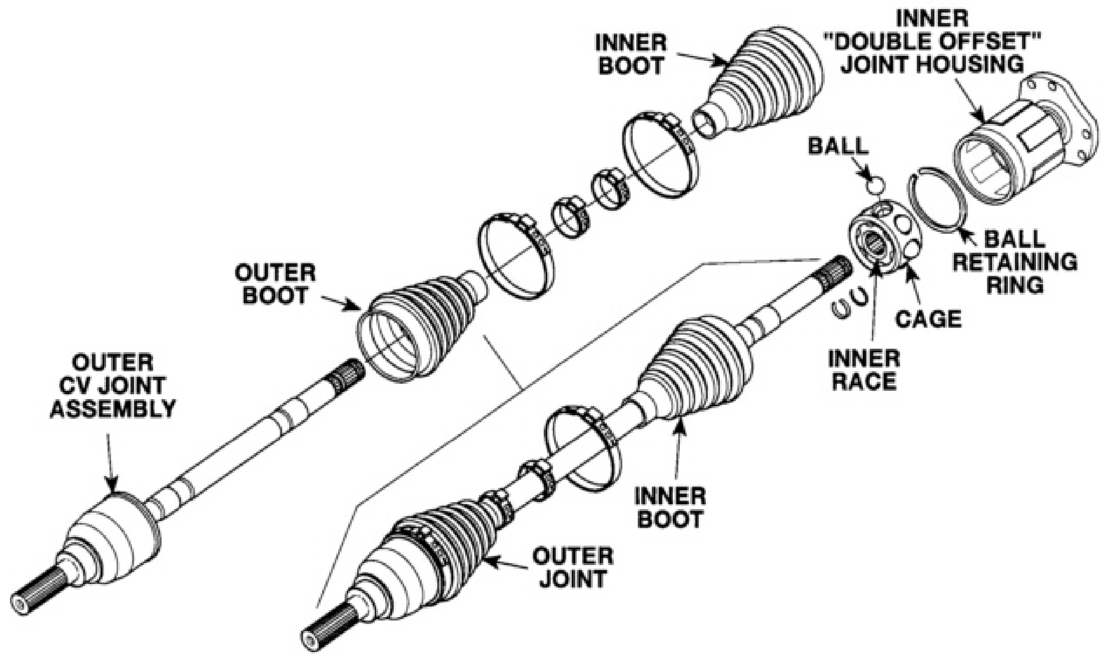

Figure 2.1 : Exploded view of a Rzeppa CV joint

2.1.2 Tripod Constant Velocity Joint

A tripod or ball and housing CV joint consists of a spider, usually three balls, needle bearings, outer yoke, and boot. The inner spider is splined to the axle shaft with the needle bearings and three balls fitting around the spider. The yoke then slides over the balls. Slots in the yoke allow the balls to slide in and out and also swivel. During operation, the axle shaft turns the spider and ball assembly. The balls transfer power to the outer housing. Since the outer housing is connected to the axle stub shaft or hub, power is sent through the joint to propel the vehicle.

2.1.2.1 Center Support Bearings

When two or more drive shafts are connected in tandem, their alignment is maintained by a rubber bushed center support bearing. The center support bearing bolts to the frame or underbody of the vehicle. It supports the center of the drive shaft where the two shafts come together. A sealed ball bearing allows the drive shaft to spin freely. The outside of the ball bearing is held by a thick, rubber, doughnut-shaped mount. The rubber mount prevents vibration and noise from transferring into the operator's compartment. A bearing similar to the center support bearing is often used with long drive lines, containing a single drive shaft. This bearing is called a pillow block bearing

It is commonly used in drive lines that power auxiliary equipment. Its purpose is to provide support for the drive shaft and maintain alignment. When used at or near the center of the shaft, it reduces the whipping tendency of the shaft at high speed or when under heavy loads. The construction of pillow blocks varies. The simplest form is used on solid power takeoff drive shafts, which is no more than a steel sleeve with a bronze bushing

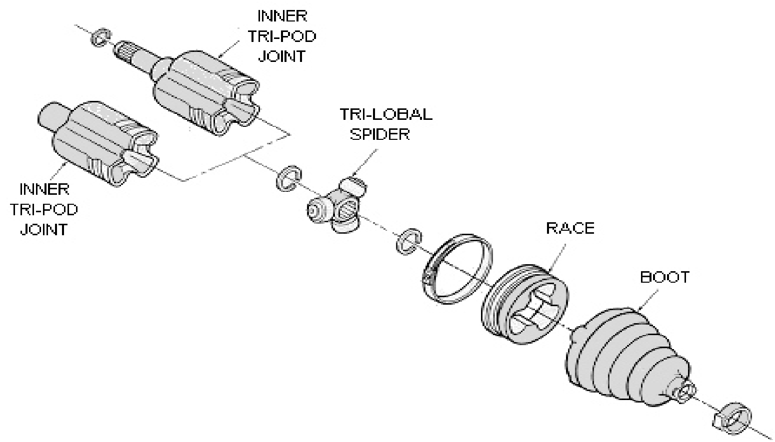

Figure 2.2: Exploded view of a Tripod CV joint

2.1.3 Bendix –Weiss

The Bendix-Weiss constant velocity (CV) joint also uses balls that furnish points of driving contact, but its construction differs from that of the Rzeppa in that the balls are a tight fit between two halves of the coupling and that no cage is use. The center ball rotates on a pin inserted in the outer race and serves Bendix-Weiss Constant Velocity (CV) Joint as a locking medium for the four other balls. The driving contact remains on the plane that bisects the angle between the two shafts; however, it is the rolling friction between the four balls and the universal joint housing that positions the balls. When both shafts are in line, that is, at an angle of 180 degrees, the balls lie in a plane that is 90 degrees to the shafts. If the driving shaft remains in the original position, any movement of the driven shaft will cause the balls to move one half of the angular distance. For example, when the driven shaft moves through an angle of 20 degrees, the angle between the two shafts is reduced to 160 degrees. The balls will move 10 degrees in the same direction, and the angle between the driving shaft and the plane in which the balls lie will be reduced to 80 degrees. This action fulfills the requirement that the balls lie in the plane that bisects the angle of drive.

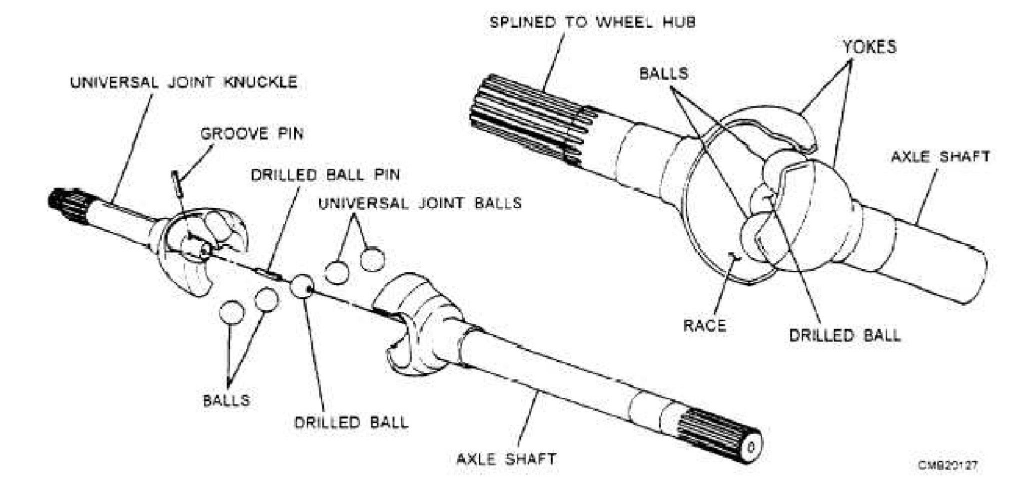

Figure 2.3: Exploded view of a Bendix – Weiss

2.1.4 Double – offset

The double - offset is another pluge joint commonly used as the inner joint on FWD shaft. It consists of an inner race, six steel balls, a cage and an outer race. Except for the outer race, which is relatively long and straight, this joint resembles o Rzeppa joint. [16]

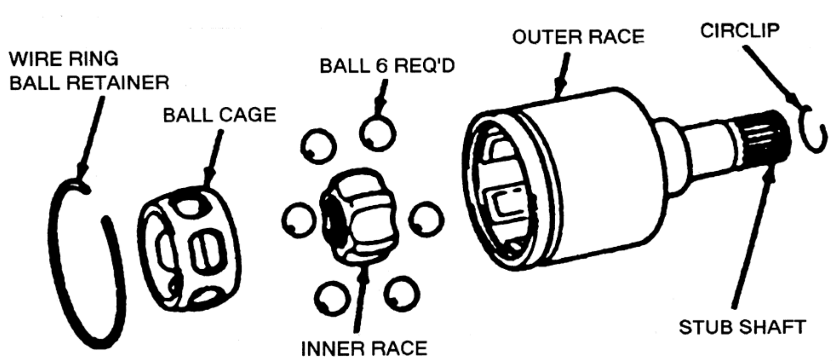

Figure 2.4: Exploded view of a Double Offset CV joint